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Effects of Artificially Drying Seed Cotton on Certain Quality Elements of Cottonseed in Storage.

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INTRODUCTION

The problem of handling and storing cottonseed after ginning is of vital importance to farmers, ginners, and cottonseed processors. Conditions under which seed is stored, in a large measure determine its ultimate quality regardless of the purpose for which the seed is to be used. Excessive moisture content and high temperature of cottonseed are known to have appreciable effects on quality changes that sometimes occur during storage. Unless these and other conditions are ideal, free fatty acids may develop in the seed. These acids must be held to a minimum if prime quality oil is to be extracted from the seed.

Some of the unexplained damage and overheating of cotton seed has been attributed to recently developed methods in use at many gins for artificially drying seed cotton. The United States Cotton Ginning

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[1] Acknowledgments are made to Richard T. Doughtie, Jr., cottonseed technologist, Agricultural Marketing Administration for suggestions in formulating the study; to T. G. Weiss, supervisor, Barrow-Agee Laboratory, Leland, Miss., for assistance in checking the free fatty acid determinations; and to coworkers of the U. S. Cotton Ginning Laboratory for assistance in providing the material through their regular ginning activities.

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Laboratory at Stoneville, Miss., initiated a 2 year study in 1939 to ascertain the effect of the drying process on certain factors of seed storage, such as temperature, moisture, free fatty acids, and viability.

The making of this study offered the opportunity to investigate at the same time the formation of free fatty acids in cottonseed—a matter of importance to persons interested in the problem of seed deterioration. Numerous studies have been made and several theories have been advanced, but as yet there appears to be no conclusive evidence as to the exact mechanism and importance of the various factors involved in the formation of free fatty acids.

REVIEW OF LITERATURE

Freyer (*4*) [2] correlated moisture content with free fatty acid development. For cottonseed having a moisture content above 12.5 percent, he found that the tendency to deteriorate increased; but despite this tendency he concluded that the presence of excess moisture did not necessarily mean that free fatty acids would develop in any specific sample of seed.

Olcott and Fontaine (*8*) believe hydrolysis is the main, if not the only, source of free fatty acids. They were unable to find any lipase in cottonseed by known methods of analysis.

O'Kelly and Hull (*7*) showed that free fatty acids increased with weather damage. In their experiments cottons in the first harvest had an average free fatty acid content of less than 1 percent; and 2 months later, the sixth harvest of the same cottons contained more than 3 percent.

Robertson and Campbell (*9*) destroyed the germinative power of cottonseed and found such seed was more likely to develop free fatty acids when exposed to moisture than was live seed when similarly exposed.

Meloy (*6*) advanced the hypothesis that under normal weather conditions the plant juices dehydrate and cause the enzymes in cottonseed to become dormant; but when this process is prevented by excessive atmospheric humidity, the enzymic activity continues until it becomes a destructive agent, causing the development of free fatty acids. He found that if normal dehydration does occur, the enzymes are not so readily reactivated by increases in seed moisture content.

Simpson (*11*) concluded that the formation of free fatty acids depends directly upon the moisture and temperature of the seed in storage. His data show a rapid rise in free fatty acids with increased moisture and also with increased storage temperature. In seed lots containing more than 1.8 percent free fatty acids, the seed failed to germinate.

It is apparent that many investigators are of the opinion that excess moisture is largely responsible for excess free fatty acids. If this is true, then the artificial drying of seed cotton should affect the production of free fatty acids in cottonseed, and the laboratory's study of seed storage as related to drying should provide some indication of this.

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[2] Italic numbers in parentheses refer to Literature Cited, p. 17.

METHOD OF STUDY

Storage tests of cottonseed were conducted in connection with the regular ginning tests relating to the artificial drying of seed cotton prior to ginning. In 1939, selected lots of seed ginned from 16 cottons were used, each cotton representing four conditions: undried, and dried respectively at 160°, 190°, and 220° F. A 17-floor vertical tower drier was used wherein the seed cotton was exposed to heated air for a period of approximately 15 seconds.[3]

Immediately after the seed cotton was ginned, 100-pound lots of seed were placed in large metal drums. In each drum a heavy cardboard mailing tube, perforated at the lower end, was inserted to two-thirds of the depth of the seed mass, and an accurate mercury thermometer attached to a string was placed inside the tube. The upper end of the tube extended 1 to 2 inches above the seed and the entire top of the drum was covered with a tightly woven burlap sack. To eliminate partially the effect of temperature variations at ground level, the lots were stored in small bins having concrete floors, in the second story of a well-sealed cotton house.

Although the laboratory's study employed comparatively small lots of seed, the use of metal drums as containers tended to approximate the conditions of commercial storage. The drums were airtight except for the top opening and thus the air circulating through the seed was held to a minimum. Additional tests were run with the drums insulated by embedding them in loose cottonseed to a depth of 3 feet. Results obtained were almost identical with those without this added insulation. It should be noted, however, that the element of high pressure found in bulk storage is not reproduced with the set-up described.

At the time of storage, representative samples were taken from each seed lot and analyzed for moisture and free fatty acid content. Moisture determinations were made according to the procedure of the American Society for Testing Materials (*1*) by means of electrical conditioning ovens. Moisture content is expressed as percent of wet weight of the seed. Analyses for free fatty acids were made in accordance with the method recommended by the Agricultural Marketing Administration[4], and check samples were run periodically by a licensed commercial seed-testing laboratory.

The study was enlarged in 1940 to include several methods of conveying the seed from the gin to the storage bins. In addition to removing the seed from the gin stands by a flat belt and carrying 100 pounds of seed in burlap sacks by hand to storage, as in 1939, the seed was removed by blowing it under two conditions approximately 100 feet through a 10-inch pipe: (1) with unheated air, and (2) with air heated to 120° F. A fourth lot ginned from the seed cotton dried at 220° F. was blown with air heated to 180°. Laboratory analyses were expanded in 1940 to include tests at the time of ginning and after 15, 30, 60, and 90 days of storage. Germination counts were made at the beginning and at the end of the 90-day storage period.

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[3] For a complete description of the drying process see (*3*).

[4] UNITED STATES AGRICULTURAL MARKETING SERVICE. METHODS OF CHEMICAL ANALYSIS AND GRADE CALCULATIONS FOR COTTONSEED. 12 pp. 1939. [Processed.]

The former Agricultural Marketing Service, except the Division of Agricultural Statistics, is now a part of the Agricultural Marketing Administration.

It should be noted that in 1939 the ginning of the seed cottons extended over a period from August 17 to October 19, and in 1940 from September 10 to November 6. This variation in ginning dates could not be avoided, as the 1940 crop matured later than in the previous year. The storage periods were therefore not coincident for the 2 years, and this discrepancy is taken into consideration throughout the study.

EFFECTS OF ARTIFICIALLY DRYING SEED COTTON ON SPECIFIED CONDITIONS AND QUALITIES OF THE GINNED SEED

In presenting the results, the different lots of cottonseed were grouped by moisture content and the data averaged for those of 12 percent and above, and for those below 12 percent in moisture content. This point of division appears to be the usual one when considering free fatty acids and moisture in seed as well as a safe condition for seed storage. In several cases in this study two seed cottons of almost identical field history, moisture content, and temperature produced high fatty acids in one cotton and low fatty acids in the other. Growing and harvesting data (table 1) were obtained on each cotton included in the study, but all attempts to correlate formation of free fatty acids with these data were unsuccessful.

Table 1.—*A partial description of seed cottons ginned to provide seed for the storage tests*

Variety	Location planted	Date planted	Soil type	Early season weather [1]	Late season weather [2]	Number days exposure in field before picking	Date harvested	Condition of cotton when ginned	Percent of moisture content of seed when ginned	Date ginned
MOISTURE CONTENT 12 PERCENT AND ABOVE, CROP OF 1939										
Delfos 6	Stoneville, Miss	Apr. 21	Fine sandy loam	Very wet	Very dry	0– 2	Aug. 14	Green	14.2	Aug. 17
Delfos 531-B	Leland, Miss	Apr. 12	Sandy loam	do	do	0– 2	do	do	15.2	Aug. 19
Coker Clevewilt	Tifton, Ga	Mar. 28	Fine sandy loam	do	Normal	0–15	Aug. 15	Wet	18.8	Aug. 21
D. P. L. 11	Montrose, Ark	May 1	Loamy sand	do	Dry	0– 2	Aug. 24	Green	16.8	Aug. 26
D. P. L. 11A	Huntsville, Ala	do	Ruston sandy loam	do	Very dry	0– 2	Sept. 19	Wet	17.6	Sept. 23
Delfos 6	Stoneville, Miss	Apr. 24	Fine sandy loam	do	do	0–32	Sept. 22	do	15.2	Sept. 24
Do	do	do	do	do	do	0–46	Oct. 5	Damp	14.2	Oct. 5
MOISTURE CONTENT BELOW 12 PERCENT, CROP OF 1939										
Delfos 6	Stoneville, Miss	Apr. 22	Fine sandy loam	Very wet	Very dry	0– 2	Aug. 17	Green	8.9	Aug. 25
Delfos 9252	Leland, Miss	Apr. 10	do	do	do	0–15	Aug. 29	Dry	9.5	Aug. 31
Missdel 7	Stoneville, Miss	Apr. 26	do	do	do	0–11	Aug. 25	Green	10.9	do
Delfos 6	do	Apr. 21	do	do	do	0–20	Sept. 5	Normal	11.4	Sept. 7
Dixie Triumph 213	Baton Rouge, La	(3)	Lintonia silt	do	Wet	0–15	Sept. 1	do	9.6	Sept. 21
Stoneville 4B	Hayti, Mo	May 1	Loam	Wet	Very dry	0– 6	Sept. 16	Green	10.6	Sept. 22
Dixie Triumph 213	Baton Rouge, La	(3)	Lintonia silt	Dry	Wet	0–17	Oct. 2	Normal	11.2	Oct. 12
Express 11384	Stoneville, Miss	Apr. 21	Fine sandy loam	Wet	Dry	0–15	Sept. 15	Dry	11.1	Oct. 16
Delfos 6	do	do	do	do	do	0– 7	Oct. 4	do	6.2	Oct. 19
MOISTURE CONTENT 12 PERCENT AND ABOVE, CROP OF 1940										
Delfos 3506	Stoneville, Miss	Apr. 25	Fine sandy loam	Wet	Wet	0– 5	Sept. 5	Very green	17.8	Sept. 10
Dixie Triumph	Baton Rouge, La	Apr. 15	Lintonia silt	Very wet	Dry	0–15	Sept. 15	Damp	15.6	Oct. 1
Delfos 4729	Stoneville, Miss	Apr. 20	Fine sandy loam	Wet	Wet	0– 7	Oct. 7	Wet	18.3	Oct. 8
Delfos 3506	do	do	do	do	Normal	0– 2	Oct. 15	Damp	15.8	Oct. 19
Do	do	Apr. 25	do	do	Wet	0–30	Nov. 4	do	14.5	Nov. 6
MOISTURE CONTENT BELOW 12 PERCENT, CROP OF 1940										
Delfos 4729	Stoneville, Miss	Apr. 8	Sharkey clay	Wet	Dry	0–11	Sept. 12	Dry	9.6	Sept. 14
Delfos 3506	do	Apr. 25	Fine sandy loam	do	do	0– 7	Sept. 16	do	11.4	Sept. 17

[1] General moisture condition for 60 days after planting.

[2] General moisture condition 15 days prior to harvesting.

[3] Data incomplete.

Temperature

The temperature of seed is important when considering deterioration, as it is well known that excessive heat may produce a condition detrimental to seed quality, especially if combined with excessive moisture. Artificial drying of seed cotton at the gin does heat the seed to some extent, but daily records reveal that in these experiments the rise in temperature as a result of the drying process was temporary. In about 3 days, natural cooling eliminated this increase and thereafter the seed lots ginned from the undried and dried seed cottons did not differ greatly in temperature (table 2). There was an average temperature of 82° F. for wet seed [5] from undried cottons at the time of ginning and an average temperature of 93° for seed from cottons dried at 220°. At the end of 90 days the undried seed was down to 55°, a decrease of 27° from the original temperature, and the dried seed was down to 54°, a decrease of 39°. A similar relationship is indicated for seed below 12 percent in moisture content.

Table 2.—*Effect of artificially drying seed cotton on the temperature of cottonseed, crops of 1939 and 1940*

MOISTURE CONTENT 12 PERCENT AND ABOVE

Condition of seed cotton	Temperature of cottonseed at ginning and at specified storage periods					
	At ginning	3 days	15 days	30 days	60 days	90 days
	°F.	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*
Undried	82	77	82	75	64	55
Dried at 160° F	88	78	82	75	65	55
Dried at 190° F	91	78	82	74	64	55
Dried at 220° F	93	78	80	73	63	54
MOISTURE CONTENT BELOW 12 PERCENT						
Undried	77	73	69	64	57	49
Dried at 160° F	85	73	69	65	57	50
Dried at 190° F	88	73	70	65	57	50
Dried at 220° F	92	74	70	65	57	50

The greatest influence on seed temperature is caused by atmospheric conditions and not by the drying process. Although the seed was stored where fluctuations in the outside air would tend to have a minimum effect on temperature, a definite tendency to follow air conditions is observed (figs. 1 and 2). In considering figures 1 and 2, it should be remembered that no two lots of seed had identical storage periods. To obtain the daily average temperature of all the stored samples within the two specified moisture ranges, the temperatures for each consecutive day of storage of the individual samples were used. For example, the sample of undried, wet seed from lot 1 had a temperature of 82° F. on the first day of storage, August 17; the comparable sample from lot 2, a temperature of 80° on the first day of storage, August 19; that from lot 3 had 85°, etc., which resulted in an average of 82° for this specific day of storage.

The procedure described was followed to calculate the average temperature for each drying condition every day during the 90-day period, in both 1939 and 1940. Similarly, maximum and minimum temperatures were averaged from daily readings of a United States Weather Bureau recording thermometer located near the storage building. Although no official records are available, the relative humidity of the locality is comparatively high, usually from 55 to 70 percent in the afternoon.

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[5] The term "wet seed" refers to seed with a moisture content of 12 percent and above.

The average difference between maximum and minimum atmospheric temperatures on wet seed in 1939 was 26°, whereas in 1940 it was 23° F. The difference on dry seed averaged 24° in 1939 and 25° in 1940. The maximum temperatures during the 1939 storage tests averaged 82° on wet seed and 70° on dry seed, as compared with 69° and 74° F., respectively, in 1940. Minimum temperatures were higher in 1939 than in 1940.

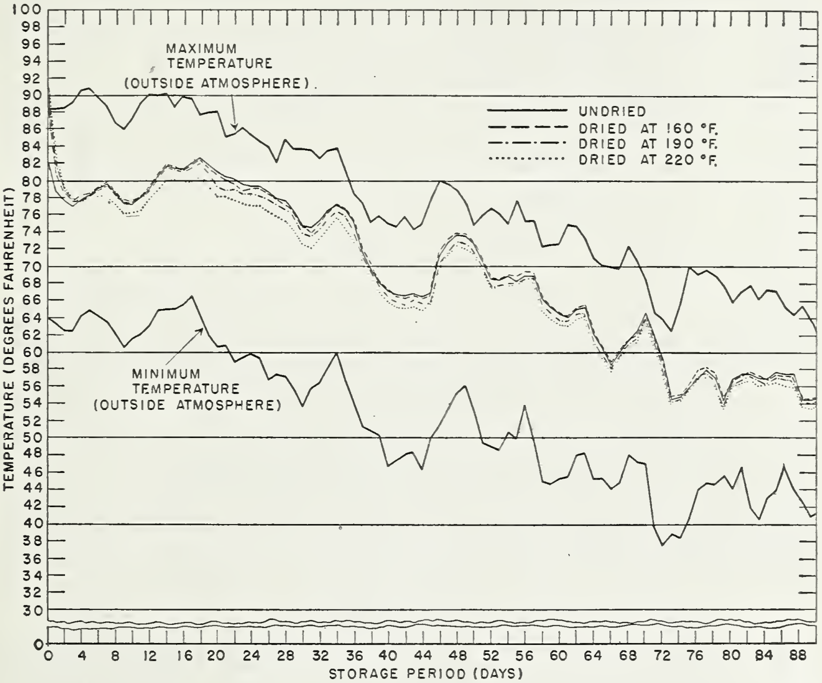

FIGURE 1.—Average temperature of cottonseed during storage—moisture content 12 percent and above, crops of 1939 and 1940.

Because rather wide ranges of moisture and temperature of both seed and air were combined for the 2 years, figures 1 and 2 are indicative only of general trends. It is clearly indicated, however, that for both moisture groups seed temperatures varied directly with air temperatures, and followed air temperatures with a slight lag. At no time after the first few days did the seed from dried lots differ more than 2° F. from the seed of undried lots. There appears to be a relatively constant temperature differential of 5° to 12° F. between seed from the high- and low-moisture groups. Apparently this continued higher temperature of the wet seed is due to the inherent

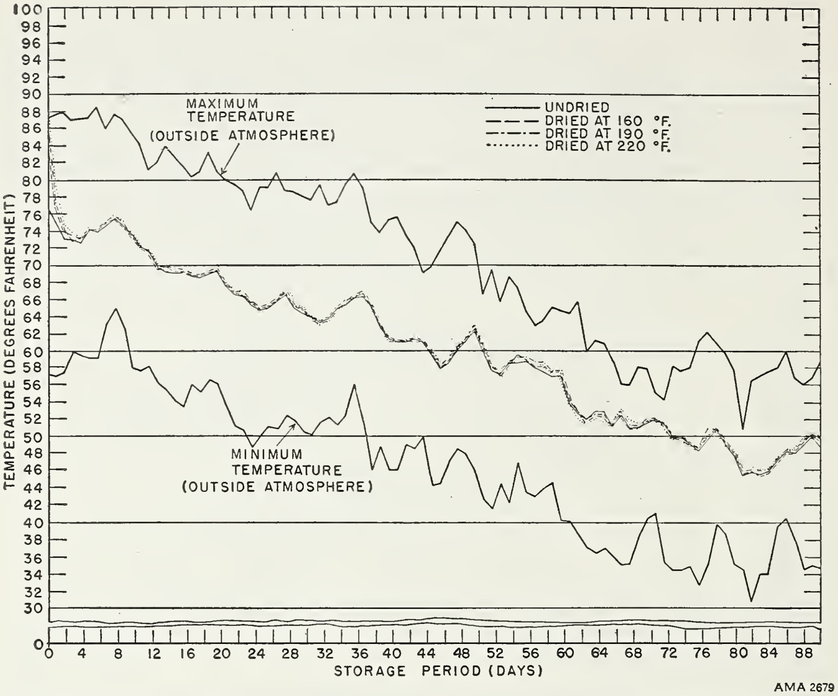

FIGURE 2.—Average temperature of cottonseed during storage—moisture content below 12 percent, crops of 1939 and 1940.

heating of the seed caused by excessive moisture and rate of respiration; that phase will be discussed later.

MOISTURE

The drying equipment at cotton gins is designed for use on seed cotton and its effect on seed is relatively small. At the time of ginning, drying caused decreases in moisture of four-tenths to seven-tenths of 1 percent in the seed ginned from the cotton of high moisture content (table 3). Ninety days later there was essentially no difference between the undried and dried lots; and an average loss of 1 percent moisture in this wet seed is shown for the entire storage period, irrespective of the handling condition.

In the low-moisture group very little difference in moisture content of the different lots of seed was noted at the completion of the storage period. The dried seed gained moisture, the undried seed lost moisture, and ultimately both lots reached the same level of moisture content.

TABLE 3.—*Effects of artificially drying seed cotton on the moisture content of cottonseed, crops of 1939 and 1940*

MOISTURE CONTENT 12 PERCENT AND ABOVE

Condition of seed cotton	Moisture content of cottonseed		
	At ginning	After 90 days' storage	Difference
	Percent	*Percent*	*Percent*
Undried	15.7	14.5	−1.2
Dried at 160° F	15.1	14.3	−.8
Dried at 190° F	15.3	14.1	−1.2
Dried at 220° F	15.0	14.1	−.9
MOISTURE CONTENT BELOW 12 PERCENT			
Undried	10.3	9.7	−0.6
Dried at 160° F	9.2	9.6	+.4
Dried at 190° F	9.1	9.5	+.4
Dried at 220° F	9.7	9.6	−.1

FREE FATTY ACIDS

Free fatty acids have a detrimental effect on the grade given to the seed, and it is to the advantage of farmers, ginners, and oil millers to use every method of handling and storing that may assist in retarding the development of these acids. The grade of seed is reduced because the quality of the oil is lower when excess fatty acids are present.

Results of the 2-year study indicate that drying seed cotton inhibits the development of free fatty acids in stored wet seed (table 4). Each year, the percentage of free fatty acids at the time of ginning was the same in seed ginned from undried and dried seed cottons. The 1939 tests showed that seed from undried cottons had from 1.7 to 7 percent more fatty acids after 90 days' storage than seed from dried cottons. The 1940 tests showed a difference of 2.1 to 2.7 percent. Free fatty acids did not develop in stored seed of low moisture content.

TABLE 4.—*Effects of artificially drying seed cotton on the free fatty acid content of cottonseed*

MOISTURE CONTENT 12 PERCENT AND ABOVE

Condition of seed cotton	Free fatty acid content of cottonseed					
	At ginning		After 90 days' storage		Difference	
	1939	1940	1939	1940	1939	1940
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Undried	1.0	0.4	19.3	5.4	18.3	5.0
Dried at 160° F	1.0	.4	17.6	3.3	16.6	2.9
Dried at 190° F	1.0	.4	16.0	2.9	15.0	2.5
Dried at 220° F	1.0	.4	12.3	2.7	11.3	2.3
MOISTURE CONTENT BELOW 12 PERCENT						
Undried	0.9	0.2	1.0	0.3	0.1	0.1
Dried at 160° F	1.0	.2	1.0	.4	.0	.2
Dried at 190° F	1.0	.2	1.0	.3	.0	.1
Dried at 220° F	1.0	.2	1.0	.4	.0	.2

The development of free fatty acids in wet seed varies inversely with the temperature employed in the process of artificially drying seed cotton prior to ginning (fig. 3). It is noticeable that the percentage of free fatty acids continues to increase with the length of storage of undried wet seed; with wet seed from cotton that has been artificially dried, the increase is proportionately less up to 60 days, after which the increase of free fatty acid content is negligible in seed dried at 190° and 220° F. Regardless of the temperature applied, the drying process does not reduce free fatty acids already present in the seed.

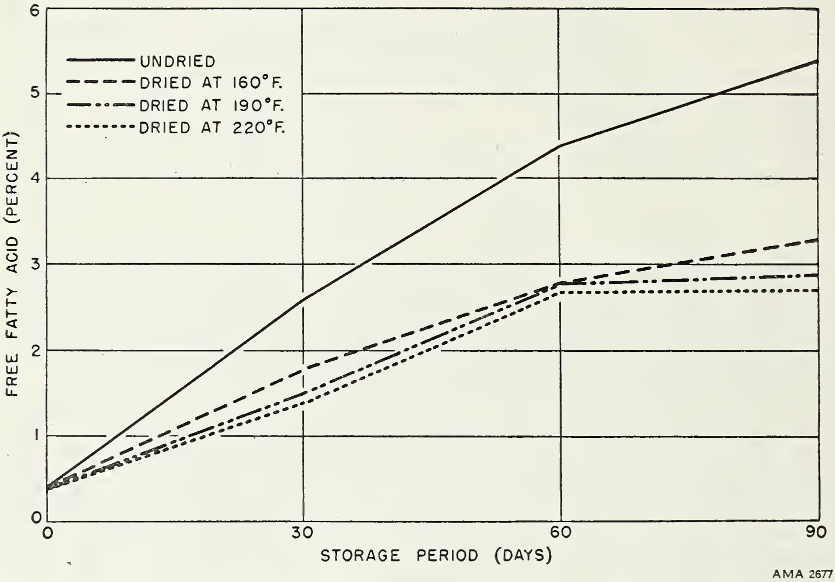

FIGURE 3.—Retardation of the formation of free fatty acid in cottonseed with a moisture content of 12 percent and above, during storage, as a result of artificially drying the seed cotton prior to ginning.

Although 220° F. gave the best results on seed storage, it should be remembered that the use of such an excessive temperature in drying seed cotton generally injures the lint, and it is preferable, therefore, to use moderate temperatures (160° F.) even though the retardation of the development of free fatty acids during storage of wet seed may be slightly less.

As heretofore pointed out, the factors determining formation of free fatty acids are not definitely known. It is apparent that both moisture and temperature are interdependent in affecting the development of these acids in cottonseed in storage. Other pertinent factors, however, such as the period of dampness of the seed prior to storage, the effect of rate of respiration on temperature of seed, and the physiological changes within seed also affect deterioration.

A recent study (*11*) shows that moisture and temperature are directly related to deterioration. Wet and dry seed were stored for 2 years under four conditions of constant temperature. The resulting data indicate that free fatty acid development increases directly with increased temperature or increased moisture, and is highest with a combination of excessive moisture and temperature. Seed containing 1.8 percent free fatty acids did not germinate.

Similar results were obtained in the studies made at the United States Cotton Ginning Laboratory and here reported. Of the seven cottons of high moisture content used in 1939, four were ginned in August and two were ginned in September. The seed from these cottons was in storage during a period of relatively high atmospheric temperature. The following year this condition was reversed when four of the five wet cottons used were ginned after September 30 and the seed was stored under comparatively low temperatures. Although seed ginned from these cottons had practically the same moisture content in both years, it is noticeable that the free fatty acids in them were very much higher in 1939 than in 1940 (table 4). Conditions of moisture, handling, and storing being the same each year, it appears logical to assume that the higher temperatures prevailing throughout the 1939 storage period were responsible for the increased seed deterioration over that of 1940. The effect of moisture on free fatty acid development is shown by the fact that seed below 12 percent in moisture content did not deteriorate, regardless of the atmospheric temperature.

The decreases in seed moisture as a result of drying seed cotton may seem rather small to cause the retardation of free fatty acid development from 2 to 7 percent. In this connection, the influence of moisture on the rate of seed respiration should be considered. Bailey and Gurjar (*2*) made a comprehensive study of respiration of stored wheat and found that with wheat above 14 or 15 percent in moisture content, very slight additional increases in moisture content made very large increases in the rate of respiration. As the rate of respiration increased, the release of heat energy also increased. Seed is a poor conductor of heat and therefore any additional heat accumulates in the mass of seed and raises its temperature. Conversely, a slight decrease in moisture of damp seed causes a large decrease in respiration and heat energy. This interrelationship holds true also for cottonseed in storage.

It may be seen in figure 1 that wet seed from cotton subjected to the drying treatment is consistently lower in temperature than undried seed. In other words, although drying causes only a small reduction in seed moisture, this reduction may have a decided effect on decreasing the respiration rate which in turn influences seed temperature. Therefore, with reduced moisture and reduced temperature, the formation of free fatty acids is retarded since its development is associated with high moisture and high temperature.

Regardless of the underlying reason, however, these results show that the artificial drying of seed cotton at cotton gins has beneficial effects on cottonseed, and they tend to disprove any theory that the drying process may cause seed to deteriorate in storage.

VALUE OF ARTIFICIAL DRYING

The monetary loss from the deterioration of seed of high moisture content may be considerable for farmers or ginners who retain their seed for several months before selling it to the oil mills, or for oil mill operators who store seed without cooling or drying for long periods before milling. The expense of cooling and drying wet seed in an effort to hold down deterioration may be reduced to some extent by storing seed ginned from artificially dried cotton.

By drying wet seed cottons prior to ginning, the losses in value to the sellers because of seed deterioration after 90 days' storage were reduced by $2.49 to $6.25 per ton (table 5). It is not advisable, however, to store seed from cottons of high moisture content, regardless of the preginning treatment, as there is usually a decrease in the value of such seed when it is kept under average storage conditions.

TABLE 5.—*Losses in value of wet cottonseed after 90 days' storage, due to free fatty acids, crops of 1939 and 1940*

Condition of seed cotton	Free fatty acids of cottonseed	Loss in value per ton [1]
	Percent	*Dollars*
Undried	12.4	13.37
Dried at 160° F	10.5	10.88
Dried at 190° F	9.4	9.62
Dried at 220° F	7.5	7.12

[1] Based on seed at $25 per ton and calculated with basis grade for ammonia, oil, and foreign matter.

The Bureau of the Census reports 5,258,500 tons of cottonseed produced during the season ended July 1940. Of this quantity, 4,150,755 tons, having a value of $159,212,000, were crushed. The exact tonnage of this seed, purchased by oil mills on the basis of grades as determined under regulations of the Agricultural Marketing Administration is not known, but in the Mississippi Valley area approximately 1,700,000 tons [6] were marketed in this manner.

Under the system prescribed by the Agricultural Marketing Administration, cottonseed purchased by oil mills is first chemically analyzed in licensed commercial testing laboratories and the mills then pay the sellers a price based on the laboratory analysis. The standard grades are based primarily on the amounts of oil and protein found in the seed as related to basis amounts of these materials. Premiums are paid for extra amounts of oil and protein. Discounts are based chiefly on the quality of the oil in the seed as indicated by the percentage of free fatty acids in the oil. Other grade elements remaining the same, the grade of the seed decreases rapidly as the free fatty acids increase, because the refining losses to the oil mills increase in direct proportion to the free fatty acids. For example, in seed with 11.5 percent fatty acids a minimum of about one-fourth of the crude oil is suitable only for soap stock; in fact, it is called soap stock. The market price for this oil is much lower than that for good grade refined oil, just as linters sell for less than lint cotton; so, to protect themselves, the oil mills pay less when buying seed containing such oil.

Furthermore, in areas where the licensed grading system does not prevail, seed is bought on one average price, which is held down to take care of the batches of deteriorated seed that are of less value. This average price is lower than the base price under the seed grading system, and the seller who has good seed which should draw a premium is penalized by hog-round buying.

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[6] Estimated from cottonseed inspection and market news reports, Agricultural Marketing Administration.

Viability of Seed

The farmer who retains his seed for planting purposes naturally is interested in handling the seed in a manner conducive to preserving the highest possible germination. Table 6 indicates that the drying of seed cotton has some influence on viability. When tested for germinative properties immediately after ginning, both wet and dry seed showed favorable reactions to the higher drying temperatures, substantiating similar results obtained during other drying tests (*5*).

Table 6.—*Effects of artificially drying seed cotton on the germination of cottonseed, crop of 1940*

MOISTURE CONTENT 12 PERCENT AND ABOVE

Condition of seed cotton	Germination of cottonseed	
	At ginning	After 90 days' storage
	Percent	*Percent*
Undried	59	56
Dried at 160° F	64	54
Dried at 190° F	69	59
Dried at 220° F	66	62

MOISTURE CONTENT BELOW 12 PERCENT

Condition of seed cotton	At ginning	After 90 days' storage
Undried	76	90
Dried at 160° F	86	94
Dried at 190° F	85	94
Dried at 220° F	87	94

At the time of ginning, the undried wet seed had an average germination count of 59 percent, whereas that of the dried seed averaged 66 percent, a difference of 7 percent. The average count for undried seed of low moisture was 76 percent and for dried seed it was 86 percent, a difference of 10 percent in favor of drying. At the end of 90 days, for wet seed, these average differences dropped to 2 percent in favor of drying, and for dry seed to 4 percent in favor of drying.

Cottonseed from freshly opened bolls usually shows a degree of dormancy and must pass through an after-ripening process before prompt germination can be obtained (*10*). This initial dormancy disappears after natural drying and a short period of storage. It is possible that the process of artificially drying seed cotton, brief as it is, may be responsible for breaking this dormancy and thus increasing the seed germination.

EFFECTS OF DIFFERENT METHODS OF CONVEYING COTTONSEED FROM THE GIN STANDS TO STORAGE ON THE CONDITION AND QUALITY OF THE SEED

As previously pointed out, the seed from the dried cotton was higher in temperature than the seed from the undried cotton at the time of ginning. In 1940, when unheated air was used in conveying the seed from the gin stands to storage, the temperature of the seed was slightly lower than when the seed was moved on a flat belt.

When leaky separators allow hot air to be drawn from the conveying air which moves the seed cotton from a chamber below the separators to the drying chambers, the conveying air of unloading-fan exhausts frequently reaches 120° F. Air of this temperature, used to convey dried seed, caused the seed to increase a few degrees in temperature by the time it reached storage (table 7). When seed ginned from dried seed cotton was conveyed by air heated to 180° F., an extreme condition, the seed temperature rise was still only 6° as compared with the temperature of the seed handled by a flat belt. At the end of 90 days' storage the temperature of the seed handled by all methods dropped to about 53° or 54° F. In most instances the unheated seed-conveying air slightly reduced the moisture content of the seed when conveying it from the gin stands to storage, and in all instances the heated air caused some slight reduction in the moisture content of the seed. At the end of 90 days' storage the seed handled by both unheated and heated air was generally slightly lower in moisture content than the seed removed from the gin stands by the flat belt without the use of conveying air.

TABLE 7.—*Effects of different methods of conveying cottonseed from the gin stands to storage on the condition and quality of the cottonseed, crop of 1940*

MOISTURE CONTENT 12 PERCENT AND ABOVE

Condition of seed cotton	Method of conveying seed from gin stands to storage	Temperature		Moisture		Free fatty acids		Germination	
		At ginning	After 90 days' storage	At ginning	After 90 days' storage	At ginning	After 90 days' storage	At ginning	After 90 days' storage
		° F.	*° F.*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Undried	Flat belt	72	54	16.4	15.0	0.4	5.4	59	56
Do	Unheated air	72	54	15.7	14.7	.4	4.2	61	48
Dried at 160° F	Flat belt	80	54	16.4	14.9	.4	3.3	64	54
Do	Unheated air	79	54	15.5	14.6	.4	3.8	62	56
Do	Air at 120° F	83	54	15.9	14.4	.4	3.1	68	60
Dried at 190° F	Flat belt	83	54	16.1	14.2	.4	2.9	69	59
Do	Unheated air	81	53	15.0	13.7	.4	3.2	66	59
Do	Air at 120° F	84	53	15.8	14.1	.4	3.1	61	60
Dried at 220° F	Flat belt	85	53	15.8	14.0	.4	2.7	66	62
Do	Unheated air	83	54	16.0	13.2	.4	2.8	65	63
Do	Air at 120° F	86	53	14.9	13.9	.4	2.7	71	59
Do	Air at 180° F	91	53	15.1	13.0	.4	2.7	66	63
MOISTURE CONTENT BELOW 12 PERCENT									
Undried	Flat belt	82	60	10.5	9.2	0.2	0.3	76	90
Do	Unheated air	83	60	10.3	9.5	.2	.4	87	92
Dried at 160° F	Flat belt	94	60	9.0	10.0	.2	.4	86	94
Do	Unheated air	92	61	8.3	8.3	.2	.4	86	91
Do	Air at 120° F	94	60	8.8	9.3	.2	.3	86	94
Dried at 190° F	Flat belt	98	60	8.9	8.6	.2	.3	85	94
Do	Unheated air	95	60	9.5	9.2	.2	.4	92	94
Do	Air at 120° F	98	60	9.3	8.2	.2	.5	86	96
Dried at 220° F	Flat belt	98	60	9.5	9.5	.2	.3	87	94
Do	Unheated air	97	60	9.3	10.3	.3	.4	79	91
Do	Air at 120° F	98	60	9.8	9.4	.2	.3	85	94
Do	Air at 180° F	102	60	9.5	9.8	.2	.3	84	94

The slight difference in moisture content between the seed handled by the different conveying methods was not sufficient to cause any significant difference in the free fatty acid content of the cottonseed at the end of the 90-day storage period.

Germination percentage of the seed after 90 days' storage was not materially affected by the different methods of handling the seed from the gins. The differences in germination were small and inconsistent.

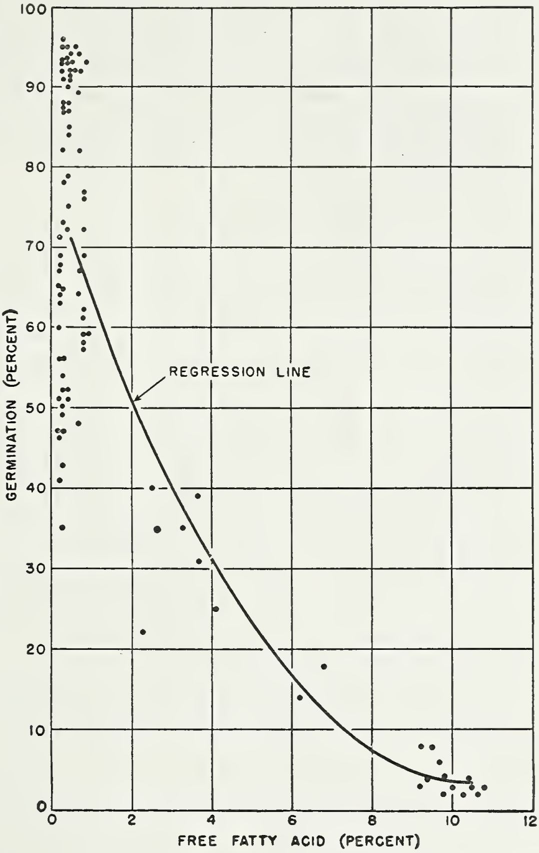

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FIGURE 4.—Reduction in germination of cottonseed possessing a moisture content of 12 percent and above as a result of increasing percentages of free fatty acid in the seed.

RELATIONSHIP BETWEEN GERMINATIVE PROPERTIES OF THE COTTONSEED AND FREE FATTY ACID CONTENT

In studying the individual cottons of the test, it was observed that cottonseed which developed high free fatty acids seemed to have a tendency toward low germination. In figure 4 the percentage of germination is plotted against the percentage of free fatty acids for 94 samples. Most of the observations that are grouped around 50 percent germination and three-tenths of 1 percent free fatty acids came from one exceptionally green and damp cotton; in all the other cottons low fatty acid content usually was associated with high germination. The regression line indicates that a free fatty acid content of 2 percent becomes critical as far as cottonseed germination is concerned.

Although excessive free fatty acid content may not in itself be the direct cause of low germination, it can be used as an index of viability since the factors responsible for free fatty acid formation also affect viability. As previously stated, these factors are moisture, rate of respiration, and temperature of seed. It can be said, therefore, that a high percentage of free fatty acids is indicative of seed not suitable for planting purposes.

SUMMARY

The conditions under which cottonseed is stored have an important bearing on the quality of the seed after prolonged periods of storage. Excessive moisture content and overheating of the seed not only have an ultimate adverse effect on the quality of oil extracted from stored seed but they may also influence its germinative properties.

In 1939 unconfirmed reports came to the United States Cotton Ginning Laboratory to the effect that the process of artificially drying seed cotton at gins presented serious problems in seed storage at oil mills and caused undesirable increases in the free fatty acid content of the seed. Studies designed to duplicate the conditions of oil-mill and cotton-gin seed storages were made in an effort to obtain data under controlled conditions to refute or confirm these reports.

Results of the 2-year study, in which 23 cottons were used, have been compiled and analyzed. They indicate that with green, damp, or wet seed cottons, the process of artificially drying before ginning did not cause an increase in the rate of deterioration of the seed in storage; that in fact, it caused retardation of the formation of free fatty acids. The higher the drying temperature used, the less was the free fatty acid content of the seed at the end of the 90-day storage period.

The seed from cottons picked and ginned in a dry condition did not show a significant change in free fatty acids during the 90 days of storage, and the added removal of moisture by artificial drying therefore did not influence this property in the dry seed.

Artificial drying of seed cotton at the gin caused temperature rises in the ginned seed that ranged from 6° F. with a drying air temperature of 160° to 11° with a temperature of 220° on seed lots 12 percent or higher in moisture content, and respective rises of 8° to 15° F. with seed having less than 12 percent moisture. In a few days natural cooling eliminated most of the differences; and thereafter the seed lots ginned from undried damp cottons were slightly higher in temperature than those from the dried damp cottons, while seed from the undried and dried cottons of low moisture content had practically the same temperatures.

Drying the wet cottons at the time of ginning with an air temperature of 220° F. caused a maximum moisture removal in the seed of seven-tenths of 1 percent. At the end of 90 days' storage the differences in moisture content between the undried and dried lots were reduced somewhat; the undried seed lost 1.2 percent of moisture and the seed representing the high drying temperature, nine-tenths of 1 percent. In the seed ginned from the dry cotton, very little difference in moisture content was noted at the end of the storage period. The dried seed gained moisture, the undried seed lost moisture, and all lots ultimately reached the same level of moisture content.

Germination tests on the undried and dried seed indicated that drying improved the germination percentage of the seed, whether at the time of ginning or after 90 days' storage.

Cottonseed which developed high free fatty acid content seemed to have a tendency toward low germination. The data indicate that a free fatty acid content of 2 percent becomes critical as far as cottonseed germination is concerned.

The effect of conveying the seed from the gin stands to storage by means of unheated and heated air was very slight. As compared with conveying on a flat belt, unheated air used to move the seed caused a slight decrease in seed temperature. Conveying air heated to 120° F. resulted in an increase of only a few degrees in seed temperature, and conveying air at 180° caused a rise in temperature that did not exceed 6° on an average for seed 12 percent or higher in moisture content. These increases were only temporary, and they disappeared in 3 or 4 days.

In most instances the use of air in conveying the seed caused a slight reduction in moisture content of wet seed, but the reductions were generally too small to be significant. The moisture and temperature effects were also insignificant with dry seed; and the free fatty acid content and germination of both wet and dry seed after 90 days' storage were not materially affected by the different methods of conveying the seed.

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